[0053] In a preferred embodiment, the structure **14** and active material element **16** are integrated. For example, the structure **14** may be formed of a shape memory polymer that would enable selective softening of and memorized return to the folded condition by the structure **14**. This would allow retention of the deformation without external force (i.e., zero-power hold). That is to say, the rigidity of the structure **14** can be increased, and/or the force necessary to deform the surface **12** reduced. In general, the SMP would be molded into the folding pattern and more folded condition in its deactivated state, then flattened by receiving a sufficient force vector input after activation, and then locked into the flattened condition by deactivating the SMP while retaining the input. To return the structure **14** to the more folded condition, the SMP is again activated without the input.

[0054] Where shape memory polymer is employed, the structure **14** preferably includes embedded heating elements (e.g., wires or patches) **24** which create localized heating and transformation (FIG. **6**). Localized soft and hard regions may be used to define a variable folding pattern on the surface **12** that can be changed by energizing specific combinations of heating elements **24** and/or actuators **16**. Thus, preferential fold lines for greater variability in texture control may be provided. FIG. **6** shows a dual embodiment, wherein the structure is formed of SMP to effect selective softening/locking, and influencing of the folding pattern (together with etching, stamping, etc.), and a contractile wire **16** traverses the structure **14**, so as to effect selective folding.

[0055] In another example, the structure **14** may comprise a shape memory alloy (SMA) sheet trained to memorize the more folded condition. Here, the structure **14** may be in a normally low modulus Martensite phase, such that a low energy input causes it to flatten. When the more folded condition (FIG. **2***b*) is desired, the structure **14** is heated above its transformation temperature after the input has been removed, to recover its memorized shape. Alternatively, where the structure **14** is in the normally Austenite phase, it is appreciated that a stress load input of sufficient magnitude may be applied to cause the Austenite to Martensite phase transformation prior to flattening. Upon release of the stress load, the structure **14** reverts back to the Austenite phase and memorized shape. Finally, it is appreciated that a combination of the foregoing examples may be employed, wherein SMA forms the outer layers **26** and SMP forms the polymeric core **28**.

[0056] In another embodiment, the folded structure **14** is adhered to a compliant substrate **30** through which actuation may be realized (FIG. **7-10**). That is to say, the substrate **30** may be configured such that deforming it modifies the degree of folding within the structure **14**. The structure **14** is preferably adhered to the substrate **30** using a flexible adhesive. Preferably, the substrate **30** has a lower elastic modulus than the pre-patterned structure **14**. As such, the substrate **30** preferably provides a restoring force when deformed, and may be pre-strained. Depending on the pattern involved, the substrate **30** may be uni-axially or bi-axially pre-strained. Upon releasing the pre-strain (or decreasing monotonically) the compressive strain energy built up in the higher stiffness surface sheet **14** is relieved via the organized folding mode. To improve the folding characteristics several steps may be taken including slightly pre-biasing the deformations of the fold lines, incorporation of through holes at the vertices **14***c*, and careful selection of the structure, adhesive and substrate materials. In some instances the substrate **30** may have adhesive properties, eliminating the need for a separate adhesive. For assisted folding, it is appreciated that progressive jigs and tools may be employed.

[0057] In this configuration, the preferred actuator **16** is drivenly coupled to the substrate **30**, and more preferably, through opposite end caps **32**. The end caps **32** coextend with a lateral edge of the substrate **30** (FIGS. **7-9**), so that the actuating force is transferred evenly. The end caps **32** are fixedly secured relative to the substrate **30** and may be anchored therein via over-molded engaging prongs (not shown). In a first example, the actuator **16** includes at least one, and more preferably a plurality of shape memory wires/tendons formed for example of SMA, EAP, etc. that are embedded within, so as to traverse the full width of the substrate **30** (FIG. **7**). More preferably, a single wire **16** is entrained by the end caps **32** to form multiple loops along the length of the substrate **30**. Here, the wire **16**, when activated, promotes uniform translation, thereby causing the caps **32** to travel towards each other without eccentricity. Where a thermally activated actuator **16** is used, it is appreciated that the substrate **30** is able to withstand the anticipated number of heating-cooling cycles without degradation. To that end, a barrier (not shown), such as a thermally insulating sleeve, may be used to envelope the wire **16** and protect the substrate **30**.

[0058] In another example, the actuator **16** is externally coupled to, and configured to retentively displace at least one cap **32** (FIG. **8**). An SMA wire **16**, for example, may be employed to pull a cap **32** and stretch the substrate **30**, wherein the wire **16** is lengthened/redirected through at least one pulley (not shown) as necessary. To increase the amplitude and reduce wavelength (i.e., compress the structure **14**) a piezoelectric stack sandwiched between an end cap **32** and fixed structure may be caused to expand when activated; or an arcuate SMA or EAP element **16** (FIG. **10**) that straightens when activated may be used to compress the substrate **30**. Finally, an SMP or SMA spring (not shown) able to modify its spring constant through activation may be employed, wherein only the stiffer constant is able to overcome the compressive strength of the substrate **30**.

[0059] In another embodiment, the actuator **16** may consist of an active material sheet (or disk) disposed beneath the substrate **30** (FIG. **9**). The planar sheet **16**, for example, may be formed of SMA, so as to be operable to contract laterally in all directions. In this configuration, it is appreciated that activating the sheet **16** approximately results in a sixteen percent reduction in surface area where maximum recoverable Martensitic strain is provided. It is also appreciated that the actuator **16**, and bottom of the substrate **30** are free to allow for an increase in system depth, again, so that the surface **12** changes in texture but otherwise remains flush with surrounding surfaces. The same is true for a substrate **30** consisting of negative Poisson's ratio material.

[0060] In yet another example, the system **10** includes a rigid member **34** embedded in the substrate **30** and drivenly coupled to the actuator **16** (FIG. **10**). In the illustrated embodiment, the rigid member **34** is divided into two or more parts **34***a,b* that move in opposite directions to compress/stretch the substrate **30**. That is to say, the member **34** may be used to rectify actuation and modulate the texture, as a transmission. More particularly, an active material actuator **16**, such as the arcuate actuator shown in FIG. **10**, may be attached to a cross-bar **36** comprising a driven one of the parts **34***a,b*, to provide a push force thereto. The preferred rigid